

# METHOD AND SYSTEM FOR SIMULTANEOUS DISPLAY OF A VIDEO SEQUENCE IN MULTIPLE TIME-OFFSET WINDOWS

5

## FIELD OF THE INVENTION

The present invention relates generally to video and more specifically to a method and system for displaying simultaneously a video sequence in multiple time-offset windows.

10

## BACKGROUND OF THE INVENTION

In recent years, video applications have become increasingly popular on personal computers. Advances in processor speed, the decreasing cost of random access memory (RAM), and the advent of Digital Versatile Discs (DVDs) using the popular Motion Picture Experts Group (MPEG) compression standard have made possible a wide variety of video-related hardware and software. Digital TVs configured to receive and process digital cable TV or satellite TV signals are also becoming popular with consumers.

Recorded video, whether digital or analog, has the distinct advantage that the viewer may queue and watch a video sequence beginning at any desired point within the sequence. Video systems typically include controls such as "play," "stop," "pause," "search forward" or "fast forward," and "search backward" or "rewind." Some video systems also provide the ability to watch multiple video sequences simultaneously. For example, a computer user may watch several different MPEG video sequences at the same time on a monitor. However, whether the video system supports only one or multiple simultaneous video sequences, each video sequence appears within its own single-frame-sized viewing area on the display. If a viewer

desires to replay an earlier portion of a video sequence or to skip ahead to obtain an overview of its content, the viewer must do so within the single viewing area. In some situations, especially those involving long video sequences such as movies on DVD, searching for a specific segment or obtaining an overview of the content can require considerable time. A viewer's temporal perception of a video sequence is fundamentally limited because only one portion of the video sequence may be viewed at any given time. It is thus apparent that there is a need in the art for an improved method and system for displaying video sequences.

## SUMMARY OF THE INVENTION

A method is provided for displaying simultaneously a video sequence in multiple time-offset windows. A system is also provided to implement the method.

Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is block diagram of a computer in accordance with an exemplary embodiment of the invention.

Fig. 1B is a block diagram of a video system comprising a portion of the exemplary embodiment of the invention shown in Fig. 1A.

Fig. 2A is a diagram of a first method for organizing a buffer memory in support of multiple video windows.

Fig. 2B is a diagram of a second method for organizing a buffer memory in support of multiple video windows.

Fig. 3A is an illustration of an exemplary embodiment of the invention prior to the selection of a particular video window.

Fig. 3B is an illustration of an exemplary embodiment of the invention after the selection of a particular video window.

5 Fig. 4A is an illustration of an exemplary embodiment of the invention showing the time relationships among a set of video windows prior to the selection of a particular video window.

Fig. 4B is an illustration of an exemplary embodiment of the invention showing the time relationships among a set of video windows after a particular video  
10 window has been selected.

Fig. 4C is an illustration of an exemplary embodiment of the invention showing the time relationships among a set of video windows after the original video window has been re-selected.

Fig. 5 is flowchart showing the operation of the computer shown in Fig. 1 in  
15 accordance with an exemplary embodiment of the invention.

Fig. 6A is an illustration of another exemplary embodiment of the invention prior to the selection of particular a video window.

Fig. 6B is an illustration of another exemplary embodiment of the invention after the selection of a particular video window.

20 Fig. 7 is a flowchart of the operation of the computer shown in Fig. 1 in accordance with another exemplary embodiment of the invention.

Fig. 8 is an illustration of yet another exemplary embodiment of the invention.

Fig. 9 is a flowchart of the operation of the computer shown in Fig. 1 in accordance with yet another embodiment of the invention.

25 Fig. 10 is an illustration of a further exemplary embodiment of the invention.

Fig. 11 is a flowchart of the operation of the computer shown in Fig. 1 in accordance with a further exemplary embodiment of the invention.

Fig. 12 is an illustration of a user interface for specifying the number, configuration, and time relationships of video windows in accordance with an exemplary embodiment of the invention.

Fig. 13A is an illustration of a first user interface for adjusting the time differential between video windows while a video sequence is being displayed in accordance with an exemplary embodiment of the invention.

Fig. 13B is an illustration of a second user interface for adjusting the time differential between video windows while a video sequence is being displayed in accordance with an exemplary embodiment of the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

The invention solves the problem of a viewer being able to see only one portion of a video sequence at a time by displaying a single video sequence simultaneously in multiple time-offset video windows. Using the invention, a viewer can quickly see a single video sequence at different points in time, either delayed or time advanced. Throughout this detailed description, a video window denotes a portion of a display device devoted to displaying a single realization of a video sequence. The term, as used here, is distinct from the term “window” commonly used in connection with graphical user interfaces and computer operating systems. In the context of the present invention, the multiple video windows may all reside within a single fixed or floating computer window, in different computer windows, or outside any computer window (e.g., directly on the background or “desktop”).

Fig. 1A is a block diagram of a computer 100 in accordance with an exemplary embodiment of the invention. Central processing unit (CPU) 105 communicates via data bus 110 with random access memory (RAM) 115, audio system 120, and video system 125, which in turn outputs video and control signals to display device 130. Input device 135 is also connected to CPU 105 via data bus 110. Audio system 120 typically comprises a sound card, audio input and output jacks, and speakers. Display device 130 is typically a high-resolution color monitor. Input device 135 is typically a mouse, track ball, keyboard, or similar input device for interacting with a graphical user interface. Video system 125 will be explained in further detail.

Fig. 1B is a block diagram of an exemplary implementation of video system 125 shown in Fig. 1A. A video sequence 140 in digital format is fed via data bus 110 to video system 125. If video sequence 140 is in, for example, MPEG format, optional codec 145 converts video sequence 140 to uncompressed digital video data 148. Digital video data 148 is output to buffer memory 150. Under the direction of timing and control circuitry 155, digital video data 148 is transferred at the desired video frame rate from buffer memory 150 to display RAM 160. Display RAM 160 is organized such that each address contained therein maps to a unique pixel location on display device 130. Video interface circuit 165 converts digital video data 148 stored in display RAM 160 to a format compatible with display device 130. Typically, this involves converting digital video data to analog format and inserting timing signals such as vertical and horizontal synchronization pulses. Timing and control circuitry 155 may be implemented advantageously using a dedicated video processor.

In some situations, buffer memory 150 is large enough to contain the entire video sequence 140. In that case, displaying video sequence 140 in multiple time-

offset video windows comprises transferring portions of digital video data 148 from buffer memory 150 to display RAM 160 in accordance with the required video frame rate and the desired delay or time advance among the video windows. As those skilled in the art will recognize, this may be accomplished by a set of movable address pointers, one for each video window. In other situations, buffer memory 150 may hold only a portion of the video sequence at a time. In that case, buffer memory 150 may be organized in at least two different ways. Fig. 2A shows a first exemplary method of organizing buffer memory 150 to support multiple video windows. Buffer memory 150 is divided into N first-in, first-out (FIFO) buffers 205, one for each of N video windows. Digital video data 148 needed for display at any particular time in any given video window may be read, with the appropriate time differential  $\Delta t$  215, into the corresponding FIFO 205. Time differential  $\Delta t$ , may, in general, be a delay or a time advance. Address pointers 210 may be used to access digital video data 148 within each FIFO. Fig. 2B shows a second exemplary method of organizing buffer memory 150 to support multiple video windows. In this case buffer memory 150 comprises a single FIFO divided into two sections. First section 220 contains the oldest digital video data 148 read into the FIFO. Second section 225 contains the newest digital video data 148 loaded into the FIFO. The writing of digital video data 148 into buffer memory 150 is circular. That is, when the highest numbered address (or lowest numbered, depending on the implementation) is reached, the writing of data wraps around to the opposite end of buffer memory 150 and proceeds. First section 220 contains enough contiguous digital video data 148 to include the greatest delay or time advance. Address pointers 210 may be used to access digital video data 148 at the desired time differential  $\Delta t$  215 to support each video window. Whether buffer memory 150 is large enough to contain the entire video sequence 140 or not, it

may be advantageous in some embodiments to assign a separate operating system process or “thread” to each video window, as those skilled in the art will recognize.

Fig. 3A is an illustration of an exemplary embodiment of the invention in which four time-offset video windows 300 are displayed in a horizontal row. In this embodiment, an audio channel is associated with each video window. Each associated audio channel is synchronized with the realization of video sequence 140 shown within each video window. Four video windows have been included in the diagram of Fig. 3A for the sake of simplicity. More or as few as two video windows may be employed instead. In general, video windows 300 may be arranged in a wide variety of topologies such a single row (as in Fig. 3A), single column (vertical orientation), a grid (two-dimensional array of video windows), or any desired irregular or asymmetric pattern. Also, there is no requirement that video windows 300 be packed closely together as shown in Fig. 3A. In some embodiments, video windows 300 may be separated on display device 130. In Fig. 3A, video window 305 is the currently selected video window, meaning that the audio channel associated with video window 305 is played through audio system 120. The heavy border 308 surrounding video window 305 is used to indicate that this particular video window is currently selected for audio output. Many other possible methods of indicating selection may be employed, such as icons or other annotation, change of size relative to the other video windows, or movement to a specific area of display device 130. Cursor 310 associated with input device 135 may be used to select a different of the four video windows, thereby causing the associated audio channel to be played through audio system 120. Fig. 3B shows the embodiment of Fig. 3A after cursor 310 has been used to select video window 315. Selection may be accomplished by, for example, hovering over video window 315 with cursor 310 or by hovering over video

window 315 with cursor 310 and simultaneously depressing a button or otherwise activating a switch on input device 135. For example, hovering with cursor 310 and clicking a mouse button is one suitable implementation. Once video window 315 has been selected, the audio channel associated with video window 315 is played through audio system 120, and border 308 is moved to video window 315.

Fig. 4A shows an example of the time relationships among a set of video windows 300 in an exemplary embodiment of the invention. In Fig. 4A, each video window is delayed by time differential  $\Delta t$  215 with respect to the video window to the immediate left, as time indices 405 indicate. Therefore, each video window 300 has an associated time offset relative to an arbitrary time reference. For convenience in this detailed description, video window 305 has been chosen as the arbitrary time reference in Fig. 4A (and in Figs. 4B and 4C). Also, whether to have time progress in a left-to-right, right-to-left, up-to-down, or down-to-up fashion is a design choice that depends on the particular application of the invention. Although it is convenient, there is no requirement that every time offset be an integer multiple of a single time differential  $\Delta t$  215 with respect to an arbitrary time reference. In some embodiments, the relative time offset of each video window may be specified independently of that associated with any other video window. Fig. 4A shows the case of a progressive time delay from left to right among video windows 300. Time delays from left to right are favored in this embodiment because it is optimized for reviewing previously viewed segments of video sequence 140. In variations of this embodiments of the invention, the time offsets from left to right may be time advances instead of delays, an example of which will be given later in this detailed description. Fig. 4B shows the result of a selection operation at video window 315, as explained in connection with Fig. 3B. Time indices 405 have now advanced by elapsed time E, video



sequence 140 continues to be displayed in each video window at the indicated time index 405, and the audio channel associated with selected video window 315 is played through audio system 120. In a typical usage scenario, a viewer, while watching video sequence 140 in video window 305, desires to view again a portion of video sequence 140 that was displayed a few seconds ago in video window 305. The viewer may, for example, select video window 315 to re-watch the desired segment beginning  $2\Delta t$  ago. However, when the viewer returns to video window 305,  $E$  seconds have elapsed, and the viewer has missed part of video sequence 140. One method to solve this problem is to store in memory the time index  $T$  (405) associated with video window 305 upon the selection of video window 315. If the viewer next selects video window 305 again, as depicted in Fig. 4C, the time index 405 of each video window is reset to its state prior to the selection of video window 315 in Fig. 4B. In this way, the viewer may resume watching video sequence 140 in video window 305 without loss of continuity.

Fig. 5 is a flowchart of the operation of computer 100 in accordance with the exemplary embodiment of the invention illustrated in Figs. 3A, 3B, and 4A-4C. At 505, a viewer may optionally specify the number and spatial configuration of video windows 300. Also, a time differential  $\Delta t$  may be specified at 505. As mentioned previously, in this particular embodiment, the time differential  $\Delta t$  215 is assumed to represent a delay rather than a time advance as one moves from left to right among video windows 300. One of the video windows is marked by default as the currently selected video window at 510. Typically, the default selected video window is the earliest or latest video window in time, depending on the application. At 515, the video windows are configured and initialized on display device 130. The audio channel associated with the currently selected video window is played through audio

system 120 at 520. At 525, a test is performed to determine whether video sequence 140 has been shown in its entirety in all video windows. If so, the process terminates at 530. Otherwise, control proceeds to 535. If a request to select a different video window is received at 535, the time index 405 associated with the currently selected  
5 video window is saved at 540. At 545, the new video window chosen at 535 is marked as selected. If at 550 it is determined that the new video window selected at 535 was the previously selected video window and that the previously selected video window has a later (greater) time index 405 than the currently selected video window, control proceeds to 555. Otherwise, control returns to 515. At 555, the time indices  
10 405 of all video windows 300 are reset as explained in connection with Fig. 4C.

Figs. 6A and 6B illustrate another exemplary embodiment of the invention incorporating some features different from those already described. In Fig. 6A, video windows 300 are divided into larger primary video window 605 and smaller secondary video windows 610. Primary window 605 may, in this embodiment, be the  
15 video window for which the corresponding audio channel is output to audio system 120. Each video window, whether primary or secondary, has been numbered in Fig. 6A to indicate the relative temporal order among the video windows. In this embodiment, the video window labeled "1" may be either the earliest or the latest in time. Therefore, this particular embodiment supports either delays or time advances  
20 with respect to primary window 605. This embodiment also includes control elements 615 for controlling the playback of video sequence 140 in primary video window 605. Control elements 615 may include "play" 620, "pause" 625, "stop" 630, "search backward" 635, and "search forward" 640. Additional control elements for adjusting contrast, brightness, color balance, or video window size or for applying  
25 special effects may also be included in some embodiments. Those skilled in the art

will recognize that a single toggling control element may be used for both “play” and “pause” functions. In that case, the icon labeling the control element is the opposite of the mode currently active. In still other embodiments of the invention, control elements 615 may be replicated within each individual video window for controlling the display of video sequence 140 in that particular video window. In Fig. 6A, cursor 310 is shown hovering over the video window labeled “5.” Upon completion of a selection operation as described in connection with Fig. 3B, the configuration of Fig. 6B results. In Fig. 6B, the video window labeled “5” has been moved to primary video window 605, the video window labeled “1” has been moved to a secondary position among video windows 610, the audio channel associated with the video window labeled “1” has been muted, and the audio channel associated with the video window labeled “5” has been selected for output to audio system 120. Note that the video window labeled “1” has been reduced in size to match the size of the other secondary video windows 610.

Fig. 7 is a flowchart of the operation of computer 100 in accordance with the exemplary embodiment of the invention illustrated in Figs. 6A and 6B. Control proceeds initially in a manner similar to that in Fig. 5, except that, at 705, primary video window 605 is selected for audio output and is marked as selected by its larger size instead of by border 308. At 710, a “stop” command from control element 630 may terminate the displaying of video sequence 140 at 715. Otherwise, control proceeds to 720, where a “pause” command received from control element 625 may cause the video sequence 140 being displayed within primary video window 605 to be paused at its current time index 405 at 725. In this particular embodiment, video sequence 140 may remain paused within a particular video window, even if that video window is subsequently moved to a secondary position (610) due to the selection of a

different video window. Control then proceeds to 730, where a “play” command may resume the playing of video sequence 140 at 735 after a “pause” command at 720. At 535, a different video window, one of the secondary video windows 610, may be selected to become the new primary video window 605. If a new selection is made at 535, the video windows are resized and rearranged accordingly at 740. Otherwise, control returns to 710. If, at 745, the new video window selected at 535 had been paused prior to becoming the new primary video window 605, the time offsets of all other video windows are reset relative to the time index of the new primary video window at 750 in a manner analogous to the embodiment described in connection with Fig. 5. This approach maintains the continuity of video sequence 140 for a viewer shifting attention from one video window to another and back again. Many variations of the embodiment just described are possible. For example, secondary video windows 610 may be increased in number to completely surround primary video window 605.

Fig. 8 is an illustration of yet another exemplary embodiment of the invention. In this embodiment, a two-dimensional grid is employed to provide a large number of small video windows 300. For convenience in this detailed description, video window 805 has been designated as an arbitrary time reference in Fig. 8, with respect to which all time offsets are reckoned. Window 805 displays video sequence 140 from the beginning of video sequence 140, and all other video windows are time advanced with respect to video window 805 by an integer multiple of time differential  $\Delta t$  215. This particular embodiment is configured to provide an overview of substantially all of video sequence 140. For example, a two-hour movie on DVD may be shown simultaneously in 60 small video windows with a two-minute time differential  $\Delta t$  between adjacent video windows. A viewer may quickly identify a

section of interest within video sequence 140 by glancing at the time-offset video windows 300. This embodiment may form the basis of a powerful user interface for a video editing application, for example. In Fig. 8, video window 805 is selected for audio output and is marked with border 308.

5            Fig. 9 is a flowchart of the operation of computer 100 in accordance with the exemplary embodiment of the invention illustrated in Fig. 8. This figure is identical to Fig. 5, except that step 550 is modified at 905. In the embodiment of Fig. 9, re-selecting the previously selected video window at 535 resets the time offsets at 555 if the previously selected video window has an earlier (smaller) time index 405 than the  
10           currently selected video window. This difference results from video windows 300 being time advanced with respect to video window 805 instead of being delayed. This provision may be included to support a viewer shifting attention to a later portion of video sequence 140 and then returning to the original, earlier video window without loss of continuity. Of course, the embodiment shown in Figs. 8 and 9 may be  
15           modified to comprise a grid containing delayed video windows with respect to video window 805 instead of time-advanced video windows.

            Fig. 10 illustrates a further exemplary embodiment of the invention. In this embodiment, multiple video windows may be selected for simultaneous output to audio system 120. In Fig. 10, both video window 1005 and 1010 are selected for  
20           output of Audio A 1015 and Audio B 1020. Audio A 1015 and Audio B 1020 are mixed to form combined audio (A+B) 1025. Enabling time-delayed replicas of the audio from video sequence 140 to be played simultaneously may be useful in, for example, musical or special effects applications. Although Fig. 10 shows two selected video windows, more or even all of the video windows may be selected for  
25           audio output.

Fig. 11 is a flowchart of the operation of computer 100 in accordance with the further exemplary embodiment of the invention illustrated in Fig. 10. Control proceeds as in Fig. 5 until step 1105, in which the audio channels associated with all selected video windows are played. If a request to select an additional video window is received at 535, the additional video window is marked with border 308 and the associated audio channel is added to the audio mix played through audio system 120 at 1110. If a request to deselect a video window is received at 1115, the applicable video window is unmarked (border 308 removed), and the associated audio channel is removed from the audio mix played through audio system 120 at 1120. Deselecting an already-selected video window may, for example, be accomplished by performing a selection operation at 535 on the already-selected video window.

Fig. 12 illustrates a user interface in accordance with an exemplary embodiment of the invention. The exemplary user interface shown in Fig. 12 corresponds to a grid-style layout for video windows 300. Dialog box 1200 contains row dimension field 1205, column dimension field 1210, and time-differential radio buttons for delayed (1215) or time-advanced (1220) operation with respect to an arbitrary time reference such as, for example, the left-most, right-most, bottom-most, top-most, or center video window 300. Dialog box 1200 also contains field 1225 for entering a number of seconds or minutes for time differential  $\Delta t$  215. Radio buttons 1230 and 1235 select the units for the numerical value entered into field 1225. Virtual button 1240 finalizes the selections made within and dismisses dialog box 1200. Virtual button 1245 cancels the selections made within and dismisses dialog box 1200. Many variations are possible in a user interface such as that shown in Fig. 12. For example, instead of the video windows being specified in terms of a fixed grid,

the viewer may instead specify a number of separate, movable video windows that may be arranged on display device 130 in whatever manner the viewer desires.

Figs. 13A and 13B illustrate two different exemplary user interfaces that may be used to adjust time differential  $\Delta t$  215 while video sequence 140 is being

5 displayed. Fig. 13A shows a simple sliding control 1400. Sliding control element 1405 may be adjusted along track 1410, using input device 135, between minimum delay or time advance 1415 and maximum delay or time advance 1420. The minimum and maximum delay or time advance may be viewer specified, or these parameters may be computed based on the number of video windows and the length  
10 of video sequence 140. Fig. 13B shows an alternative method for adjusting time differential  $\Delta t$  215. In Fig. 13B, control elements 1425 and 1430 are used to increase or decrease, respectively, the numerical quantity in field 1225. As in Fig. 12, radio buttons 1230 and 1235 may be used to select the units associated with the numerical value in field 1225. Being able to adjust time differential  $\Delta t$  215 while video  
15 sequence 140 is being displayed provides considerable power and flexibility to the viewer. Using a user interface such as that shown in Fig. 13A or 13B, the viewer may decrease or increase the temporal granularity of video windows 300 to locate segments of interest rapidly.

Although the invention has been described within the environment of  
20 computer 100, the invention may also be embodied in, for example, a television set with sufficient data acquisition (sampling), memory, and processing resources. The invention may be particularly useful in such an environment for the playback of DVDs or videotapes. A digital television with sufficient memory and processing resources is also an environment in which the invention may be embodied.

The foregoing description of the present invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments of the invention except insofar as limited by the prior art.

10

11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000  
1001  
1002  
1003  
1004  
1005  
1006  
1007  
1008  
1009  
1010  
1011  
1012  
1013  
1014  
1015  
1016  
1017  
1018  
1019  
1020  
1021  
1022  
1023  
1024  
1025  
1026  
1027  
1028  
1029  
1030  
1031  
1032  
1033  
1034  
1035  
1036  
1037  
1038  
1039  
1040  
1041  
1042  
1043  
1044  
1045  
1046  
1047  
1048  
1049  
1050  
1051  
1052  
1053  
1054  
1055  
1056  
1057  
1058  
1059  
1060  
1061  
1062  
1063  
1064  
1065  
1066  
1067  
1068  
1069  
1070  
1071  
1072  
1073  
1074  
1075  
1076  
1077  
1078  
1079  
1080  
1081  
1082  
1083  
1084  
1085  
1086  
1087  
1088  
1089  
1090  
1091  
1092  
1093  
1094  
1095  
1096  
1097  
1098  
1099  
1100  
1101  
1102  
1103  
1104  
1105  
1106  
1107  
1108  
1109  
1110  
1111  
1112  
1113  
1114  
1115  
1116  
1117  
1118  
1119  
1120  
1121  
1122  
1123  
1124  
1125  
1126  
1127  
1128  
1129  
1130  
1131  
1132  
1133  
1134  
1135  
1136  
1137  
1138  
1139  
1140  
1141  
1142  
1143  
1144  
1145  
1146  
1147  
1148  
1149  
1150  
1151  
1152  
1153  
1154  
1155  
1156  
1157  
1158  
1159  
1160  
1161  
1162  
1163  
1164  
1165  
1166  
1167  
1168  
1169  
1170  
1171  
1172  
1173  
1174  
1175  
1176  
1177  
1178  
1179  
1180  
1181  
1182  
1183  
1184  
1185  
1186  
1187  
1188  
1189  
1190  
1191  
1192  
1193  
1194  
1195  
1196  
1197  
1198  
1199  
1200  
1201  
1202  
1203  
1204  
1205  
1206  
1207  
1208  
1209  
1210  
1211  
1212  
1213  
1214  
1215  
1216  
1217  
1218  
1219  
1220  
1221  
1222  
1223  
1224  
1225  
1226  
1227  
1228  
1229  
1230  
1231  
1232  
1233  
1234  
1235  
1236  
1237  
1238  
1239  
1240  
1241  
1242  
1243  
1244  
1245  
1246  
1247  
1248  
1249  
1250  
1251  
1252  
1253  
1254  
1255  
1256  
1257  
1258  
1259  
1260  
1261  
1262  
1263  
1264  
1265  
1266  
1267  
1268  
1269  
1270  
1271  
1272  
1273  
1274  
1275  
1276  
1277  
1278  
1279  
1280  
1281  
1282  
1283  
1284  
1285  
1286  
1287  
1288  
1289  
1290  
1291  
1292  
1293  
1294  
1295  
1296  
1297  
1298  
1299  
1300  
1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309  
1310  
1311  
1312  
1313  
1314  
1315  
1316  
1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326  
1327  
1328  
1329  
1330  
1331  
1332  
1333  
1334  
1335  
1336  
1337  
1338  
1339  
1340  
1341  
1342  
1343  
1344  
1345  
1346  
1347  
1348  
1349  
1350  
1351  
1352  
1353  
1354  
1355  
1356  
1357  
1358  
1359  
1360  
1361  
1362  
1363  
1364  
1365  
1366  
1367  
1368  
1369  
1370  
1371  
1372  
1373  
1374  
1375  
1376  
1377  
1378  
1379  
1380  
1381  
1382  
1383  
1384  
1385  
1386  
1387  
1388  
1389  
1390  
1391  
1392  
1393  
1394  
1395  
1396  
1397  
1398  
1399  
1400  
1401  
1402  
1403  
1404  
1405  
1406  
1407  
1408  
1409  
1410  
1411  
1412  
1413  
1414  
1415  
1416  
1417  
1418  
1419  
1420  
1421  
1422  
1423  
1424  
1425  
1426  
1427  
1428  
1429  
1430  
1431  
1432  
1433  
1434  
1435  
1436  
1437  
1438  
1439  
1440  
1441  
1442  
1443  
1444  
1445  
1446  
1447  
1448  
1449  
1450  
1451  
1452  
1453  
1454  
1455  
1456  
1457  
1458  
1459  
1460  
1461  
1462  
1463  
1464  
1465  
1466  
1467  
1468  
1469  
1470  
1471  
1472  
1473  
1474  
1475  
1476  
1477  
1478  
1479  
1480  
1481  
1482  
1483  
1484  
1485  
1486  
1487  
1488  
1489  
1490  
1491  
1492  
1493  
1494  
1495  
1496  
1497  
1498  
1499  
1500  
1501  
1502  
1503  
1504  
1505  
1506  
1507  
1508  
1509  
1510  
1511  
1512  
1513  
1514  
1515  
1516  
1517  
1518  
1519  
1520  
1521  
1522  
1523  
1524  
1525  
1526  
1527  
1528  
1529  
1530  
1531  
1532  
1533  
1534  
1535  
1536  
1537  
1538  
1539  
1540  
1541  
1542  
1543  
1544  
1545  
1546  
1547  
1548  
1549  
1550  
1551  
1552  
1553  
1554  
1555  
1556  
1557  
1558  
1559  
1560  
1561  
1562  
1563  
1564  
1565  
1566  
1567  
1568  
1569  
1570  
1571  
1572  
1573  
1574  
1575  
1576  
1577  
1578  
1579  
1580  
1581  
1582  
1583  
1584  
1585  
1586  
1587  
1588  
1589  
1590  
1591  
1592  
1593  
1594  
1595  
1596  
1597  
1598  
1599  
1600  
1601  
1602  
1603  
1604  
1605  
1606  
1607  
1608  
1609  
1610  
1611  
1612  
1613  
1614  
1615  
1616  
1617  
1618  
1619  
1620  
1621  
1622  
1623  
1624  
1625  
1626  
1627  
1628  
1629  
1630  
1631  
1632  
1633  
1634  
1635  
1636  
1637  
1638  
1639  
1640  
1641  
1642  
1643  
1644  
1645  
1646  
1647  
1648  
1649  
1650  
1651  
1652  
1653  
1654  
1655  
1656  
1657  
1658  
1659  
1660  
1661  
1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669  
1670  
1671  
1672  
1673  
1674  
1675  
1676  
1677  
1678  
1679  
1680  
1681  
1682  
1683  
1684  
1685  
1686  
1687  
1688  
1689  
1690  
1691  
1692  
1693  
1694  
1695  
1696  
1697  
1698  
1699  
1700  
1701  
1702  
1703  
1704  
1705  
1706  
1707  
1708  
1709  
1710  
1711  
1712  
1713  
1714  
1715  
1716  
1717  
1718  
1719  
1720  
1721  
1722  
1723  
1724  
1725  
1726  
1727  
1728  
1729  
1730  
1731  
1732  
1733  
1734  
1735  
1736  
1737  
1738  
1739  
1740  
1741  
1742  
1743  
1744  
1745  
1746  
1747  
1748  
1749  
1750  
1751  
1752  
1753  
1754  
1755  
1756  
1757  
1758  
1759  
1760  
1761  
1762  
1763  
1764  
1765  
1766  
1767  
1768  
1769  
1770  
1771  
1772  
1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780  
1781  
1782  
1783  
1784  
1785  
1786  
1787  
1788  
1789  
1790  
1791  
1792  
1793  
1794  
1795  
1796  
1797  
1798  
1799  
1800  
1801  
1802  
1803  
1804  
1805  
1806  
1807  
1808  
1809  
1810  
1811  
1812  
1813  
1814  
1815  
1816  
1817  
1818  
1819  
1820  
1821  
1822  
1823  
1824  
1825  
1826  
1827  
1828  
1829  
1830  
1831  
1832  
1833  
1834  
1835  
1836  
1837  
1838  
1839  
1840  
1841  
1842  
1843  
1844  
1845  
1846  
1847  
1848  
1849  
1850  
1851  
1852  
1853  
1854  
1855  
1856  
1857  
1858  
1859  
1860  
1861  
1862  
1863  
1864  
1865  
1866  
1867  
1868  
1869  
1870  
1871  
1872  
1873  
1874  
1875  
1876  
1877  
1878  
1879  
1880  
1881  
1882  
1883  
1884  
1885  
1886  
1887  
1888  
1889  
1890  
1891  
1892  
1893  
1894  
1895  
1896  
1897  
1898  
1899  
1900  
1901  
1902  
1903  
1904  
1905  
1906  
1907  
1908  
1909  
1910  
1911  
1912  
1913  
1914  
1915  
1916  
1917  
1918  
1919  
1920  
1921  
1922  
1923  
1924  
1925  
1926  
1927  
1928  
1929  
1930  
1931  
1932  
1933  
1934  
1935  
1936  
1937  
1938  
1939  
1940  
1941  
1942  
1943  
1944  
1945  
1946  
1947  
1948  
1949  
1950  
1951  
1952  
1953  
1954  
1955  
1956  
1957  
1958  
1959  
1960  
1961  
1962  
1963  
1964  
1965  
1966  
1967  
1968  
1969  
1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025  
2026  
2027  
2028  
2029  
2030  
2031  
2032  
2033  
2034  
2035  
2036  
2037  
2038  
2039  
2040  
2041  
2042  
2043  
2044  
2045  
2046  
2047  
2048  
2049  
2050  
2051  
2052  
2053  
2054  
2055  
2056  
2057  
2058  
2059  
2060  
2061  
2062  
2063  
2064  
2065  
2066  
2067  
2068  
2069  
2070  
2071  
2072  
2073  
2074  
2075  
2076  
2077  
2078  
2079  
2080  
2081  
2082  
2083  
2084  
2085  
2086  
2087  
2088  
2089  
2090  
2091  
2092  
2093  
2094  
2095  
2096  
2097  
2098  
2099  
2100  
2101  
2102  
2103  
2104  
2105  
2106  
2107  
2108  
2109  
2110  
2111  
2112  
2113  
2114  
2115  
2116  
2117  
2118  
2119  
2120  
2121  
2122  
2123  
2124  
2125  
2126  
2127  
2128  
2129  
2130  
2131  
2132  
2133  
2134  
2135  
2136  
2137  
2138  
2139  
2140  
2141  
2142  
2143  
2144  
2145  
2146  
2147  
2148  
2149  
2150  
2151  
2152  
2153  
2154  
2155  
2156  
2157  
2158  
2159  
2160  
2161  
2162  
2163  
2164  
2165  
2166  
2167  
2168  
2169  
2170  
2171  
2172  
2173  
2174  
2175  
2176  
2177  
2178  
2179  
2180  
2181  
2182  
2183  
2184  
2185  
2186  
2187  
2188  
2189  
2190  
2191  
2192  
2193  
2194  
2195  
2196  
2197  
2198  
2199  
2200  
2201  
2202  
2203  
2204  
2205  
2206  
2207  
2208  
2209  
2210